Examining Economies of Scale in School Consolidation: Assessment of Indiana School Districts

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ABSTRACT

This article examines the potential for reducing costs through school district consolidation by employing economies of scale. Utilizing Indiana school district data primarily from 2004 through 2006, we find evidence for scale economies with optimal enrollment being 1,942 students, with a per pupil estimated cost at $9,414. The 95% confidence interval of the optimal enrollment is 1,300 to 2,903 students. The study examines several hypotheses discussed in this line of literature. Transportation does not appear to hold significant scale economies potential, while salary data provides mixed results. Finally, attendance is shown to be negatively influenced by school district enrollment levels, with the impact of attendance on student performance being examined in a subsequent study.

INTRODUCTION

School administrators have the difficult task of balancing the educational requirements of students at a cost which is amenable to the district's citizenry. Providing an appropriate level of educational services within a budget constraint provides administrators an incentive to explore options to increase efficiency. School consolidation is viewed as a means to improve efficiency—Indiana has joined several others states in examining and promoting the merits of school consolidation.

School consolidation as a means to exploit economies of scale and reduce per pupil costs has an extensive history of research and application. Though the pace of consolidation has slowed since 1970,[1] there still exist many state-level

1. S. Gold et al. 1995. *Public school finance programs of the United States and Canada, 1993–94* (Volume 1. Albany NY: Center for the Study of the States).

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incentives promoting consolidation. Illinois[2] and South Dakota[3] are examples of such efforts. As indicated above, Indiana is recommending school consolidation for districts with less than 2,000 students and is currently funding a limited number of grants[4] to school districts who want to study potential consolidation with neighboring districts. The incentives these states are promoting ensure that consolidation will remain an active policy issue in efforts to reduce costs and raise student performance well into the future.[5]

BACKGROUND AND RATIONALE

A considerable amount of current research examines economies and diseconomies of scale in the provision of local education. This research uses a cost function similar to that of Duncombe et al.[6,7,8] Total per pupil cost is described as quadratic, with a squared enrollment term to test for scale economies or diseconomies. The method is applied to data for Indiana school districts, often referred to as school corporations in Indiana, from 2004 to 2006.

The results of this analysis are compared with those of previous studies to determine if they are consistent with findings of optimal enrollment levels between 2,000 to 6,000 students.[9,10,11,12,13,14] The results indicate that economies of scale do not lead to lower per pupil costs in perpetuity. As enrollment rises, diseconomies emerge. In examining cost segments for the potential of diseconomies, an often cited source of diseconomies is transportation.[15] School district land area may expand in order to increase enrollment. Added transportation requirements may eventually raise costs, creating diseconomies.

2. http://www.isbe.state.il.us/news/2005/jan.26.05.htm

3. http://doe.sd.gov/ofm/reorg/docs/CI_Description.pdf

4. $100,000 in 2008 and again in 2009

5. E. Haller and D. Monk. 1988. "New Reforms, Old Reforms, and the Consolidation of Small Rural Schools" *Educational Administration Quarterly* 24: 470-483.

6. W. Duncombe et al. 1995. "Potential cost savings from school district consolidation: A case study of New York" *Economics of Education Review* 14: 265-284.

7. W. Duncombe et al. 1996. "Alternative Approaches to Measuring the Cost of Education" *Holding Schools Accountable: Performance Based Reform in Education* (Edited by H.Ladd Washington DC: Brookings Institution).

8. W. Duncombe and J. Yinger. 2001. *Does School District Consolidation Cut Costs?* Working Paper No. 33 (Center for Policy Research, Maxwell School of Citizenship and Public Affairs, Syracuse University).

9. E. Cohn. 1968. "Economies of Scale in Iowa High School Operations" *The Journal of Human Resources* Vol. 3, 4: 422-434.

10. W. Duncombe et al. 1995.

11. W. Duncombe et al. 1996.

12. W. Duncombe and J. Yinger. 2001.

13. W. Fox. 1981. "Reviewing economies of scale in education" *Journal of Education Finance* 6: 273-296.

14. M. Imerman and D. Otto. 2003. A Preliminary Investigation of School District Expenditures with Respect to School District Size in Iowa Working Paper (Department of Economics, Iowa State University).

15. L. Kenny. 1982. "Economies of scale in schooling" *Economics of Education Review* 2: 1-24.

Teacher salaries and parent/student apathy are other potential sources of diseconomies. Although originally thought to be a source of scale economies,[16] recent research indicates that teacher salaries are a source of diseconomies.[17] Wasylenko[18] argues that size empowers employers to utilize monopsony and gain volume discounts. This is consistent with the results of a study of rural Arkansas school districts and teacher salaries.[19] But Tholkes[20] finds that larger enrollment reduces union transaction costs, encouraging teachers' unions to form and grow stronger.

Cotton[21] argues that a consequence of district consolidation is the replacement of parental and student input by ever increasing layers of bureaucracy, which leads to increased apathy. Apathetic parents are less likely to monitor district costs or student performance. Smaller districts allow for fewer formal rules and more flexibility. The result is greater involvement by teachers and parents, which increases performance and reduces costs.[22,23]

Astone and McLanahan[24] and Sewell and Shah[25] argue that student attendance is a good indicator of the parent and student involvement with a school, or with the learning process. Attendance can be used to test whether enrollment size affects the level of involvement—or apathy in its absence—and whether it leads to increased per pupil costs. The strength of the argument depends on the validity of attendance as an involvement proxy measure.

This study employs a direct and inflexible method of cost estimation. Duncombe et al.[26,27,28] utilize this approach to model the cost function, while allowing for identified endogenous variables. Similar approaches are used by

16. M. Wasylenko. 1977. "Some Evidence of the Elasticity of Supply of Policemen and Firefighters" *Urban Affairs Quarterly* 12: 365-379.

17. R. Tholkes. 1991. "Economies of scale in rural school district reorganization" *Journal of Education Finance* 16: 497-514.

18. M. Wasylenko. 1977.

19. M. Dodson and T. Garrett. 2004. "Inefficient Education Spending in Public School Districts: A Case for Consolidation?" *Contemporary Economic Policy* 22(2): 270-280.

20. R. Tholkes. 1991.

21. K. Cotton. 1996. "Affective and social benefits of small-scale schooling" *Eric Digest* EDO-RC-96-5.

22. Ibid.

23. R. Barker and R. Gump. 1964. *Big school, small school; High school size and student behavior* Stanford, CA: Stanford University Press.

24. N. Astone and S. McLanahan. 1991. "Family Structure, Parental Practices and High School Completion" *American Sociological Review* 56(3): 309-320.

25. W. Sewell and V. Shah. 1967. "Socioeconomic Status, Intelligence, and the Attainment of Higher Education" *Sociology of Education* 40(1): 1-23.

26. W. Duncombe et al. 1995.

27. W. Duncombe et al. 1996.

28. W. Duncombe and J. Yinger. 2001.

other researchers.[29,30,31]

Though the direct method dominates the literature, other research uses flexible functional forms to examine both primary/secondary education and institutions of higher education (IHEs). Cohn et al.[32] find economies of scale in IHEs, but de Groot et al.[33] and Nelson and Hevert[34] do not. Research on primary/secondary education employing the flexible function forms have yielded results which indicate constant returns, or no potential for economies of scale.[35,36,37,38] However, this research is not directly applicable since much of the data is derived from school systems outside the U.S. or higher levels of education where structures and systems differ.

The scale economies exhibited in econometric results are further bolstered by studies employing nonparametric efficiency tests. The use of technical efficiency was first defined by Koopermans,[39] further refined by Debrue[40] and Farrell,[41] and finally adopted into math programming by use of data envelopment analysis (DEA) by Charnas et al.[42] Numerous studies have employed DEA to test technical efficiencies of school districts. These studies have provided results which are generally consistent with those from econometric analyses.

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29. T. Downes and T. Pogue. 1994. "Adjusting school aid formulas for the higher cost of education disadvantaged students" *National Tax Journal* XLVII: 89-110.

30. A. Reschovsky and J. Imazeki. 1997. "The Development of the School Finance Formulas to Guarantee the Provision of Adequate Education to Low-Income Students" In W.J. Fowler, Jr. *Developments in School Finance* Washington, DC: U.S. Department of Education 123-147.

31. M. Dodson III and T. Garrett. 2004. "Inefficient Education Spending in Public School Districts: A Case for Consolidation?" *Contemporary Economic Policy* 22(2): 270-280.

32. E. Cohn et al. 1989. "Institutions of Higher Education as Multi-Product Firms: Economics of Scale and Scope" *The Review of Economics and Statistics* 71(2): 284-290.

33. H. de Groot et al. 1991. "The Cost Structure of American Research Universities" *The Review of Economics and Statistics* 73(3): 424-431.

34. R. Nelson and T. Hevert. 1992. "Effect of Class Size on Economics of Scale and Marginal Cost in Higher Education" *Applied Economics* 25(8): 1081-1092.

35. R. Butler and D. Monk. 1985. "The cost of public schooling in New York State: The role of scale and efficiency in 1978-79" *The Journal of Human Resources* 20: 3-38.

36. E. Jimenez. 1986. "The Structure of Educational Costs: Multiproduct Cost Functions for Primary and Secondary Schools in Latin America" *Economics of Education Review* 5(1): 25-39.

37. J. Callan and R. Santerre. 1990. "The production characteristics of local public education: A multiple product and input analysis" *Southern Economic Journal* 57: 468-480.

38. D. Gyimah-Brempong and A. Gyapong. 1991. "Production of education: Are socioeconomic characteristics important factors?" *Eastern Economic Journal* XVII: 507-521.

39. T. Koopmans. 1951. "An Analysis of Production as an Efficient Combination of Activities" In T.C. Koopmans, ed. *Activity Analysis of Production and Allocation* Cowles Commission for Research in Economics Monograph No 13. New York: Wiley.

40. G. Debreu. 1951. "The Coefficient of Resource Utilization" *Econometrica* 19: 273-292.

41. M. Farrell. 1957. "The Measurement of Productive Efficiency" *Journal of the Royal Statistical Society* Series A, General 120: 253-281.

42. A. Charnes et al. 1978. "Measuring the Efficiency of Decision Making Units" *European Journal of Operational Research* 2: 429-444.

METHODOLOGY

Cross-sectional data were collected from 292 Indiana school districts over a three-year period (2004 through 2006) and arranged in a panel data set. The data were downloaded from the Indiana Department of Education website.[43] The site contains school district expenditures and revenues, and demographic and socioeconomic values obtained from the U.S. Census. Detailed variable descriptions are found in Appendix A. Some variables are taken directly from the data sources, while others (including efficiency ratios) are calculated.

A two-stage least squares (2SLS) random effects regression is used in estimation. The 2SLS model is chosen because several variables, such as teacher salary and performance[44,45,46] are endogenous and instrumented. School administrations are responsible for the level of student achievement within the district. The efforts and funds expended towards this end, including the level of teacher salaries within the district, are likely to be highly correlated with the desires of these administrators. Duncombe et al.[47,48,49] argue that teacher salaries and student performance measures will exhibit correlation with the errors terms of the cost function and therefore must be instrumented with socioeconomic and demographic data. The choice of instruments is consistent with Duncombe and Yinger[50] which heavily utilize teacher experience and surrounding labor market prices in determining teacher salaries and a student's family education level and relative stability in determining student performance. While additional work by Duncombe and Yinger[51,52] provides additional sources of instruments, including the potential of residuals as instruments, the abundance of quality instruments in this instance allows for the more direct approach.

The analysis is performed on panel data consisting of time invariant variables. A random effects model is chosen in place of a fixed-effects model to accommodate these variables. The time-invariant variables are economic agents of particular interest, and a fixed-effects model removes these variables from the analysis. The socioeconomic terms taken from census data do not vary over the length of the study. The lack of variation makes the terms time dependent and a fixed-effects

43. http://mustang.doe.state.in.us
44. W. Duncombe et al. 1995.
45. W. Duncombe et al. 1996.
46. W. Duncombe and J. Yinger. 2001.
47. W. Duncombe et al. 1995.
48. W. Duncombe et al. 1996.
49. W. Duncombe and J. Yinger. 2001.
50. Ibid.
51. W. Duncombe and J. Yinger. 1997. "Why Is It So Hard to Help Central City Schools?" *Journal of Policy Analysis and Management* 16: 85-113.
52. W. Duncombe and J. Yinger. 2000. "Financing Higher Performance Standards: The Case of New York State" *Economics of Education Review* 363-386.

model eliminates these influences. However, these variables are of interest, and to ensure their inclusion, a random effects model is employed.

A regression model analysis estimates parameters for the school district cost function. The variables in this analysis are in logarithmic form, implying the coefficients are also elasticities. Once the cost function is estimated, it is optimized (in this case minimized) across the range of variables using the coefficients computed by the regression analysis.

The regression analysis determines if the resulting cost curve is approximately quadratic. Cost economies (or diseconomies) of scale associated with school district size are identified by examining the sign, size, and significance of the estimated coefficients of enrollment and its squared term.

The second portion of the analysis attempts to find potential sources of diseconomies. A regression model analysis is employed to determine if the cost functions for transportation, teacher salaries, administrative salaries, and parent-student involvement are approximately quadratic. The test of parent-student involvement first requires an examination of the cost estimation. The sign and significance of the estimated parameter on attendance (attend) determines the influence of this variable. The cost function is then rearranged making the parent-student proxy (attend) the dependent variable. A regression analysis is completed to determine the influence of consolidation on the level of parent-student involvement. Specific procedures and formulas for each component of the analysis are outlined in the following sections.

Total Cost

Total district expenditures are divided by enrollment. The equation for the school district total per pupil expenditure (costpp) in logarithmic form is estimated as:

$$\ln(V_d) = b_0 + \sum_i b_i(\ln(X_i)) + \sum_j b_j(Y_j) + e$$

V_d : costpp
X_i : enroll, enroll2, attend, busm, pctrisk, pctpov, tesala, perf, effrte, schsize, sec, capr
where: ln(enroll2) = ln(enroll)*ln(enroll)
Y_j : metro, suburb, rural

The independent variables include cost, performance, enrollment, demographic, technological, and cost ratio measures. Appendix A provides a listing and definition of all variables names. The selection criteria for variable inclusion is the prevalence of use in previous studies, data availability, and an attempt to select variables which significantly aid in describing the cost function while providing insight into possible scale economies. The logarithmic transforms of the X_i variables are employed so that results are in elasticity form. The binary Y_j variables are not transformed and are used to gauge demographic effects.

The endogenous variables are average teacher salary (tesala) and a measure of student performance (perf). These variables are instrumented using socioeconomic and demographic variables. The first stage regressions:

$$\ln(IV_d) = b_0 + \sum_i b_i(\ln(X_i)) + \sum_j b_j(Y_j) + e$$

IV_d : tesala, perf

X_i : enroll, enroll2, attend, busm, teexp, tedays, pctrisk, pctpov, pctnomov, pctnoed, pci, effrte, schsize, sec, and capr
where: ln(enroll2) = ln(enroll)*ln(enroll)

Y_j : metro, suburb, rural

From the results of the 2SLS model, an optimization model is constructed using the estimated coefficients of the regression analysis. The model is designed as a cost minimization model and solved as a math programming problem. Enrollment (enroll) and enrollment squared (enroll2) are free variables in the model. All other explanatory variables are fixed to their mean value across the data set. The actual explanatory variable values will differ between school districts. Conditions specific to a school district that are different from the mean assumption will have an impact on the district's particular optimality.

$$\text{Minimize } \ln(V_d) = b_0 + b_1(\ln(\text{enroll})) + b_2(\ln(\text{enroll2})) + \sum_i b_i(\ln(\overline{X}_i)) + \sum_j b_j(\ln(\overline{Y}_j) + e$$

V_d : costpp

X_i : attend, busm, pctrisk, pctpov, tesala, perf, effrte, schsize, sec, capr
where: ln(enroll2) = ln(enroll)*ln(enroll)

Y_j : metro, suburb, rural

Optimal enrollment is highly specific to the assumptions made and the mean values derived from the data. An enrollment range with costs within 5% of the estimated optimal was also generated.

As suggested by Dorfman et al.,[53] a confidence interval was constructed around the optimal enrollment by employing a bootstrapping method. The actual sampling distribution of the forecast can be estimated by bootstrapping

53. H. Dorfman et al. 1990. "Confidence Intervals for Elasticities and Flexibilities: Reevaluating the Ratios of Normals Case" *American Journal of Agricultural Economics* 72(4): 1006-1017.

the entire estimation procedure. The generation of the sampling distribution allows for an appropriate confidence interval to be generated.

TRANSPORTATION COST, SALARY COST, AND PARENT-STUDENT INVOLVEMENT

The technique used to estimate the cost function of the previous section is then applied in a similar manner to estimate transportation cost, salary cost, and the parent-student involvement levels. Specifically, the two-stage least squares (2SLS) random effects model is applied to transportation, salary, and attendance data. By manipulating dependent variables (V_d and IV_d), and independent variables (X_i and Y_j) as needed, it was possible to examine how well the Indiana data set responds to some of the hypotheses brought forth in the literature.

RESULTS

Results for the total cost equation are shown in Appendix B, Table 1. Enrollment (enroll) has a negative effect on total school district costs per pupil, and enrollment squared (enroll2) has a positive effect. Both coefficients are significantly different from zero. This implies that total per pupil costs decline with increased student enrollment to an optimal point. Beyond this point, total per pupil cost rise with increased enrollment. There are economies of scale at smaller enrollment levels, and diseconomies of scale at larger enrollment levels.

The coefficient on attendance (attend) is negative and significant. An increase in attendance results in decreased per pupil costs—this is our measure of parent and student involvement in the school district. Increased parent-student involvement reduces per pupil costs.

Socioeconomic variables are significant factors in determining costs. Increases in terms of family poverty (pctrisk and pctpov) result in increased per pupil expenditures by school districts. The increased spending may be the result of added welfare needs, state aid programs, and required assistance programs.

The significant and negative coefficient on the teacher efficiency ratio (effrte) indicates that an efficiently run school district results in reduced per pupil costs. This ratio, which divides teacher expenditures by total expenditures, is an attempt to assess the proportion of costs directed to teaching and learning activities. As expected, the higher the portion afforded teaching activities, the less the overall cost of the district.

The importance of the teacher efficiency ratio (effrte) helps to validate the finding that teacher salaries (tesala) are positively correlated with per pupil costs. A higher teacher wage scale results in higher per pupil costs. The same positive and significant relationship exists between per pupil costs and the other instrumented variable, student performance (perf). The result indicates the potential for a positive relationship between student performance and expenditures.

The associated costs of extracurricular activities may be the cause of the significance of the variable which measures the share of high school students[54] in total enrollment (sec). Costs associated with teaching older students are higher, which is shown by the significant and positive coefficient of the secondary variable (sec).

Finally, the relationship between per pupil costs and school size is of interest. The school size variable (schsize) is significant and negative. In response to increased enrollment, it appears less expensive to increase school enrollment than build additional schools.

An optimization model is constructed using the regression analysis coefficients in the optimization model (Figure 1).

Optimal enrollment: 1,942 students
95% Confidence Interval: 1,300 to 2,903 students
Optimal cost per pupil: $9,413.93
Enrollment within 5% of cost optimal: 547 to 6,889 students

54. defined as grades 9 through 12

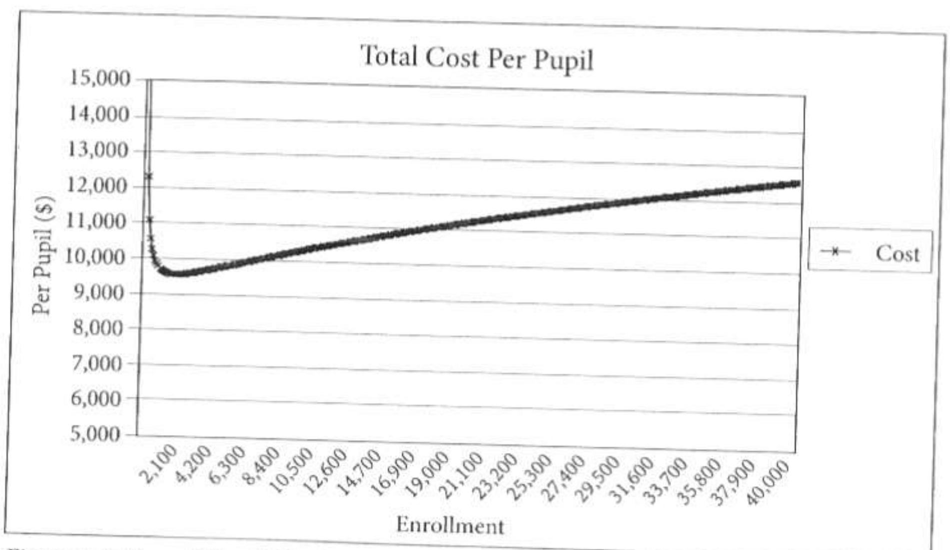

Figure 1. Indiana School District Total Cost Per Pupil

The cost function displays a U-shaped curve (quadratic and convex). Economies of scale exist up to the optimal enrollment level of 1,942 students. Beyond the optimal level, diseconomies emerge resulting in increase per pupil expenditures. The data has fewer observations above 20,000 students limiting the confidence in predicting the shape of the curve to the right of the optimal. However, it can be said with confidence that any cost benefits of consolidation quickly dissipate beyond 2,000 students and diseconomies emerge.

TRANSPORTATION COST

The regression results for transportation costs are found in Appendix B: Table 2. The transportation costs per pupil display negative significance with enrollment (enroll) and positive significance with enrollment squared (enroll2). Per pupil transportation costs exhibit efficiencies derived from increased student enrollment to an optimal point as expressed by the significant and negative coefficient of enrollment. However, beyond an optimal point, diseconomies are evidenced by an equally significant and positive coefficient of enrollment squared.

It is entirely consistent that per pupil transportation costs are significantly influenced by the bus miles of a district. The bus mile variable (busm) indicates the number of miles traveled by school district buses on an average day. The variable is significant and maintains a positive relationship with per pupil transportation costs.

Another consideration in assessing transportation costs is socioeconomic variables. Increases in family poverty (pctpov) result in increased transportation expenditures by school districts. However, this finding is mitigated by the insignificance of another socioeconomic variable. Whereas the socioeconomic condition of the serviced area is shown significant, the involvement of the student in assistance programs is not a factor in per pupil transportation costs, as seen by the insignificance of the child at risk variable (pctrisk). The role of socioeconomic status in transportation costs remains unclear.

The demographic variables (metro, suburb, and rural) are significant, positive, and roughly similar. Compared to a town, all three demographic variables increase per pupil transportation costs, with rural districts inducing the largest increase.

The significant and negative coefficient of the teacher efficiency ratio (effrte)—teaching expenditures compared to other expenditures—indicates a correlation between an efficiently run school district and reduced per pupil transportation costs. As the ratio increases, expenditures on non-teaching activities such as transportation decrease on a comparative basis. It is likely that this relationship contains more correlation than causation. The teacher efficiency ratio does not directly affect transportation costs, but is correlated.

The added transportation demands of extracurricular activities may be the cause of the positive significance of the variable that measures the grade distribution of students in the district (sec). Student involvement in extracurricular activities requires additional burdens on the transportation infrastructure. A district with a higher portion of high school students is likely to experience a higher per pupil transportation costs.

Finally, the relationship between per pupil transportation costs, school size, and capital spending is again of interest. The school size variable (schsize) is significant and negative. An argument could be maintained that more schools of smaller size should maintain students in close proximity to schools and reduce per pupil transportation costs. However, the results suggest that a larger, more concentrated school results in lower transportation costs (Figure 2).

Optimal enrollment:	27,510 students
95% Confidence Interval:	unbounded
Optimal cost per pupil:	$423.26
Enrollment within 5% of cost optimal:	7,225 to 104,737 students

The optimal enrollment level for transportation is significantly higher than the level seen with total cost. This finding indicates that additional factors must be causing significant diseconomies. The curve is shown to flatten beyond approximately 10,000 students. Significant diseconomies are shown to develop beyond 60,000 students, which is well outside the realm of the existing data.

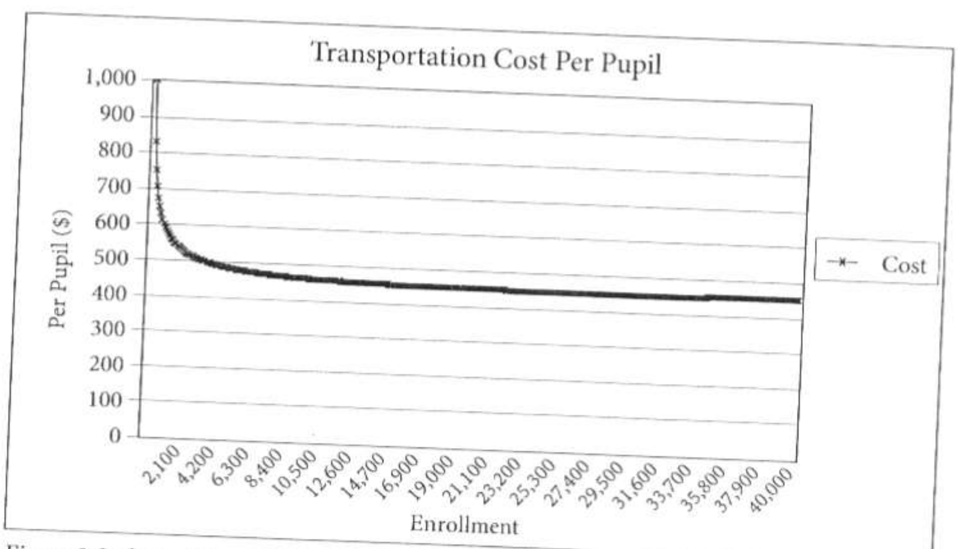

Figure 2. Indiana School District Transportation Cost Per Pupil

SALARY COST

The salary cost regressions are found in Appendix B: Tables 3, 4, 5, and 6. Annual average salaries, both for teachers and administrators are significantly influenced by enrollment size (enroll and enroll2). Salaries rise briefly at the outset of increased enrollment, but are quickly followed by decline. Socioeconomic variables (pctpov, pctrisk) are also found to significantly influence the pay scale. Districts located in areas of increased poverty are shown to have a lower pay scale.

Salaries are a major component of the annual budget of a school district, and typically constitute roughly 85–90% of the school budget. An increase in school budgets, regardless of its source, is likely to be heavily allocated to increased salaries. Similarly, since teacher salaries in aggregate dwarf those of administrative salaries, an allocation will likely favor teachers. This effect is evidenced by the significance and positive correlation of the teacher ratio (effrte). This ratio measures teaching expenditures compared to other expenditures.

An interesting result is the effect of capital expenditure (capr) and school size (schsize) on teacher salaries, both of which are positively significant. An increase in school size is seen to have a positive effect on salaries, or that larger schools tend to concentrate in larger districts with higher salaries. The results could suggest that a premium is required for teaching in larger schools.

Finally, the results suggest that a premium is required by teachers for school districts with larger numbers of lower-grade students (sec). The finding is interesting as often high school teachers earn more due to stipends and extra salary for extracurricular activities. The cause of the finding is unclear, though it might be the result of tenured teachers, with higher salaries, desiring to teach younger students. Regardless of the cause, the premium is applied only to teachers and is not carried by administrators. The grade of students is found to have no effect on administrative salaries (Figure 3).

Plotted against enrollment, annual average salaries are shown to be quadratic, concave, and share a strikingly similar path. Salaries rise initially, but quickly turn negative beyond approximately 4,000 students. The potential for these salaries to influence scale economies, however, can only be analyzed when completing the analysis in per pupil terms.

Per pupil salaries, both for teachers and administrators (Appendix 2: Tables 5 and 6) are less influenced by enrollment sizes (enroll and enroll2) than indicated in the analysis of average annual salaries. Per pupil teacher salary costs are shown to have no significance with enrollment size, perhaps the result of teacher-student ratio requirements. Per pupil administrative costs are significantly influenced by enrollment, with costs declining initially, but gradually increasing.

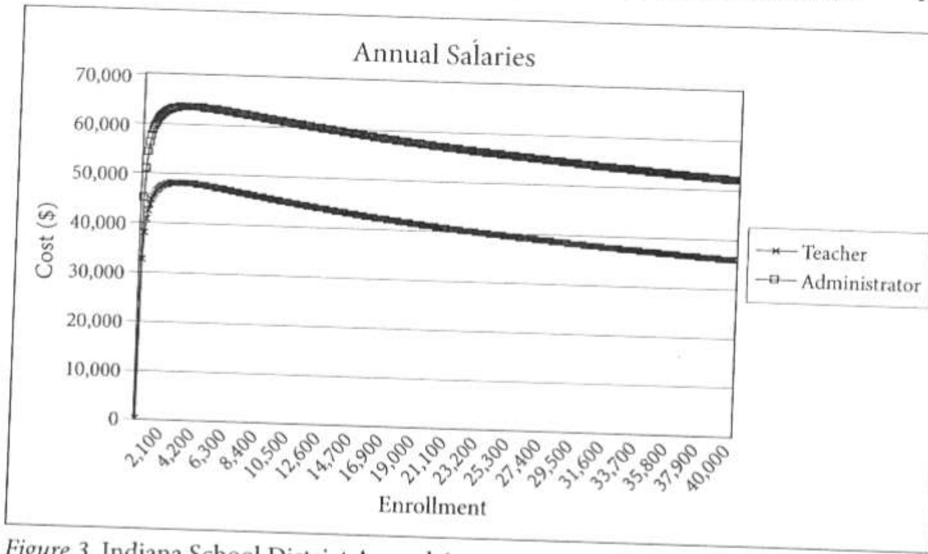

Figure 3. Indiana School District Annual Average Salaries

The bus miles variable (busm) is negatively correlated with both per pupil salary costs. As the bus miles increase, the salary levels seen in the district decrease. The results suggest that rural districts have lower administrative salaries than their more urban counterparts. The results suggest that more urban and concentrated districts are likely to see increased costs even if socioeconomic conditions are worse than their rural counterparts.

The results indicate that per pupil costs of teaching high school students are higher, while controlling for school size, as seen by the significant and positive relationship of the student distribution variable (sec). The finding could be the result of a change in the teacher-student ratio of high school students as compared to other grades, since the previous annual salary analysis indicated a discount for high school teachers. However, this effect applied only to teachers and is not carried by administrators. The grade distribution of students is found to have no significant effect on per pupil administrative costs.

Aggregate teacher salaries dominate the annual budget of a school district. It is therefore reasonable to suspect that per pupil teacher salary costs are heavily governed by the expenditure levels of school districts (costpp), and the allocation of these funds to teacher salaries (effrte), which is defined as the ratio of teacher expenditures to total expenditures. Since the governance of school districts approximately fixes the teacher/student ratio, the variation in per pupil teacher salary costs is minimal. With little measurable difference, per pupil teacher salary cost is almost exclusively a function of expenditures and allocation. This is evidenced by the extremely large significance of the per pupil cost variable (costpp) and teacher efficiency variable (effrte) (Figure 4).

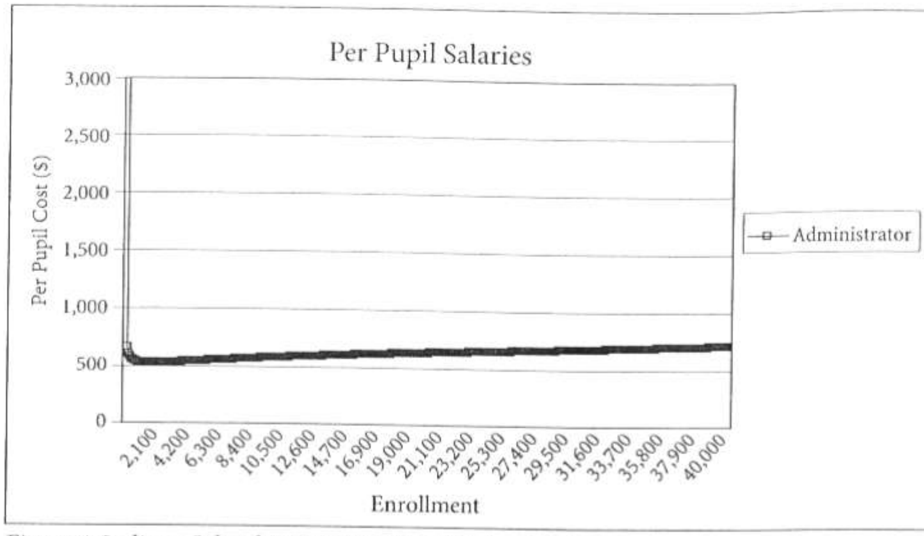

Figure 4. Indiana School District Per Pupil Salary Costs

Plotted against enrollment, per pupil salary costs functions are shown to be vastly different. Per pupil teacher salary is not significantly influenced by enrollment and is therefore not shown. Per pupil administrative salary costs is shown to be quadratic and convex. The benefits of consolidation through scale economies for per pupil administrative salary costs extend to an enrollment level of approximately 3,000 students. Beyond roughly 3,000 students, per pupil administrative salary costs exhibit signs of scale diseconomies and become a liability for further consolidation.

PARENT-STUDENT INVOLVEMENT

The regression results of student attendance are found in Appendix B: Table 7. As a proxy for parent-student involvement, student attendance is shown to be slightly influenced by enrollment size (enroll and enroll2). Attendance rises very briefly at the outset of increased enrollment, but this effect has quickly followed a prolonged decline. Socioeconomic variables, poverty (pctpov) and a lack of household education (pctnoed) are both shown to have a negative and significant effect on the attendance level of children.

The number of teaching days (tedays) has a negative relationship to attendance. Increasing the number of teaching days could result in increased student or parental fatigue, with the results an indication of this fatigue effect. The result could also question the marginal contribution of additional days of teaching in increasing performance.

Finally, attendance is shown to have a significantly positive relationship with both performance (perf) and the teaching efficiency ratio (effrte). Allocating more funds towards teaching activities, in place of administrative and extracurricular activities, seems to bolster attendance. Students performing at a high standard are also likely to maintain higher attendance (Figure 5).

Plotted against enrollment, student attendance is shown to be quadratic and concave. Attendance rates rise initially, but quickly turn negative beyond 847 students. The student attendance rate begins a long and gradual decline as enrollment increases. Beyond initial stages, enrollment and attendance maintain a negative relationship. The results of this analysis must be assessed when states consider school district consolidation policy.

CONCLUSIONS

This analysis demonstrates that the total per pupil cost function for Indiana school districts is quadratic and convex. Cost efficiencies to an optimal level of student enrollment can be obtained which will minimize per pupil costs. Beyond the optimal enrollment, however, increases in enrollment will be negatively influenced by increasing diseconomies of scale which will result in higher per pupil costs (as clearly illustrated in Figure 1).

The optimal level of student enrollment is determined to be 1,942 students at an approximate cost of $9,413.93 per student. The optimality range is slightly

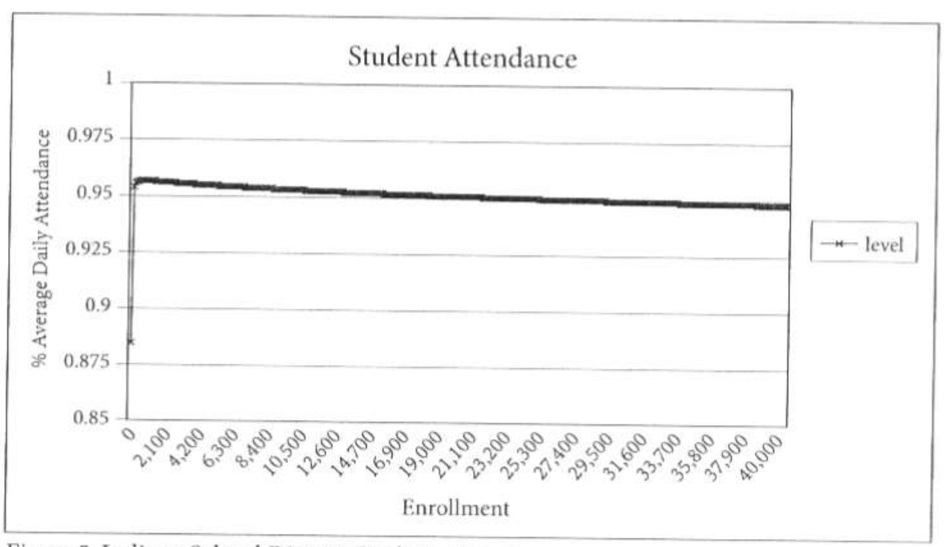

Figure 5. Indiana School District Student Attendance

below previous studies.[55,56,57,58,59,60] The 95% confidence interval of this optimal is calculated as approximately 1,300 to 2,903 students.

The findings support the claim that significant efficiencies could be realized by the consolidation of school districts with enrollment levels below 2,000 students. Of the data presented in 2006, there were 150 of the 292 school districts (approx. 51.4%) below an enrollment level of 2,000 students which could benefit from consolidation. The exact amount a particular school district could benefit from consolidation would depend on current enrollment size, with the smallest districts gaining the most efficiency. The smallest 45 school districts (approx. 15.4%) in Indiana maintain enrollment levels of less than 1,000 students, where benefits of consolidation derived from scale economies are largest (Figure 6).

Diseconomies emerge beyond an enrollment level of 2,000 students. The confidence in knowing the shape of the cost curve beyond the optimal is less, given the infrequency of observations above 20,000 students. This may slightly reduce the potential appeal of deconsolidation of larger school districts. Though the exact amount of savings might be disputed, the research is conclusive and supported by prior research in asserting that both large and small districts can suffer from scale diseconomies.

The analysis also dissects the total cost function and focuses on transportation costs as a potential source of the diseconomies. Transportation, though certainly not a source of economies, is not a large source of diseconomies and is found not

55. E. Cohn. 1968.
56. W. Duncombe et al. 1995.
57. W. Duncombe et al. 1996.
58. W. Duncombe and J. Yinger. 2001.
59. W. Fox. 1981.
60. M. Imerman and D. Otto. 2003.

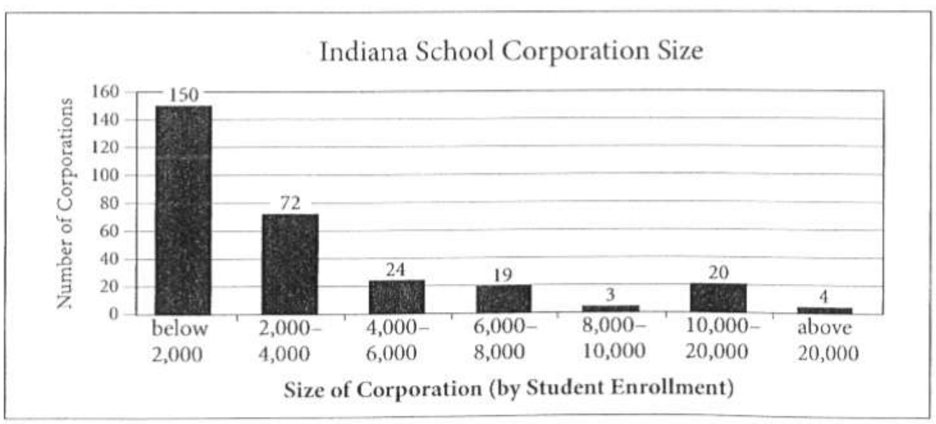

Figure 6. Indiana School District Size

to be a liability to consolidating small school districts. The relatively flat shape of the transportation curve (as shown on Figure 2) does little to support the transportation diseconomies reported by Kenny.[61]

Administrative and teacher salaries are another source of scale economies which are examined. Overall, average annual salaries appear to increase with consolidation and increased enrollment. However, once enrollment achieves a level of approximately 4,000 students, salaries peak and begin a relatively constant rate of decline (Figure 3). These results seem to substantiate the claims by both Wasylenko[62] and Tholkes[63] that, initially, transactions cost decline, and unions are likely to force consolidated school districts to "roll-up"[64] wages to the most generous of the consolidating school districts. However, as this process continues, Wasylenko's[65] argument of monopsony power gains credibility as wages are shown to decrease. If a school district is allowed to achieve a critical size, it might exert some market power on the wage scale.

When examining wages in per pupil terms, administrative wages appear to be a source of diseconomies beyond approximately 3,000 students. Per pupil administrative costs (Figure 4) are convex and quadratic. Positive scale economies are achieved through 3,000 students, followed by diseconomies. The finding is counter to arguments that assume consistently beneficial administrative cost scale economies with consolidation. Per pupil administrative costs do not decrease in perpetuity with an expansion of enrollment, and eventually begin to rise as diseconomies emerge.

Assuming attendance a viable proxy for parent-student level of involvement,[66,67] the results lend support to Cotton's[68] argument that parental-student involvement acts as an agent of cost oversight on a school district. Attendance is found to be significant and negatively related to per pupil cost (Table 1). This indicates that as the attendance rate increases or the level of parental-student involvement increases, per pupil costs decrease.

The effect of consolidation on the level of attendance and oversight is negative (Figure 5). As enrollment increases, due to consolidation, it can be expected that attendance rates for the district will decline. The contention is made that a reduction of parental/student involvement will reduce oversight on the school

61. L. Kenny. 1982.
62. M. Wasylenko. 1977.
63. R. Tholkes. 1991.
64. Ibid.
65. M. Wasylenko. 1977.
66. N. Astone and S. McLanahan. 1991.
67. W. Sewell and V. Shah. 1967.
68. K. Cotton. 1996.

district and per pupil costs should be expected to increase.[69,70]

It has been shown that a large percentage of Indiana school districts could benefit from a reduction of per pupil costs by readjusting enrollment levels across the state. However, the aims of cost reduction must be considered within the context of other academic aims and political realities. The potential cost savings of school district consolidation and its impact on student performance and the culture and identity of rural communities have statewide political implications. Assessment of these impacts is the logical progression of this research. After fully understanding the complete effects of school district consolidation, an optimal balance can be maintained between costs, achievement, social, and political considerations, which will maximize the utility of its citizenry.

69. Ibid.
70. R. Barker and R. Gump. 1964.

APPENDIX A: VARIABLE DEFINITIONS

1. enroll	corp. enrollment; 2004–2006 Class
2. attend	corp. attendance rate; 2004–2006 Class proxy for parental involvement
3. busm	corp. bus miles driven per school day; 2004–2006 Class
4. sch	corp. number of schools; 2004–2006 Class
5. dem	corp. demographic variable: 2000 Census 1 = metro, 2 = suburb, 3 = town, 4 = rural
6. sqmi	corp. square miles; 2004–2006 Class
7. teexp	corp. average teacher experience; 2004–2006 Class
8. tedays	corp. number of teacher days; 2004–2006 Class
9. pctrisk	corp. % children in at risk programs; 2000 Census
10. pctpov	corp. % parents below poverty level; 2000 Census
11. pctnomov	corp. % not moved since previous census; 2000 Census
12. pctnoed	corp. % parents no education beyond 12th grade; 2000 Census
13. pci	corp. per capita income; Yearly
14. cost	corp. total expenditures; 2004–2006 Fiscal
15. costt	corp. transportation costs; 2004–2006 Fiscal
16. adsala	corp. average administration salary; 2004–2006 Fiscal
17. tesala	corp. average teacher salary; 2004–2006 Fiscal
18. perf	corp. student performance ISTEP index; 2004–2006 Class = average % passing ISTEP English and Math grades 3,6,8,10
19. metro	demographic; 2000 Census; metro (1) = 1, other = 0
20. suburb	demographic; 2000 Census; suburb (2) = 1, other = 0
21. town	demographic; 2000 Census; town (3) = 1, other = 0
22. rural	demographic; 2000 Census; rural (4) = 1, other = 0

23. effrte	corp. efficiency ratio; 2004–2006 Fiscal = total teacher salaries / total costs (cost)
24. schsize	corp. average school size; 2004–2006 Class = enrollment (enroll) / schools (sch)
25. sec	corp. % students in grades 9–12; 2004–2006 Class = enrollment in grades 9–12 / total enrollment (enroll)
26. capr	corp. % capital expenditures; 2004–2006 Fiscal = [capital projects fund + cumulative building fund + debt service] / total cost (cost)
27. costpp	corp. cost per pupil; 2004–2006 Fiscal = total cost (cost) / enrollment (enroll)
28. costtpp	corp. transportation cost per pupil; 2004–2006 Fiscal = transportation cost (cost) / enrollment (enroll)
29. adsalpp	corp. administration cost per pupil; 2004–2006 Fiscal = administrative cost / enrollment (enroll)
30. tesalpp	corp. teacher cost per pupil; 2004–2006 Fiscal = teacher cost / enrollment (enroll)

APPENDIX B: TABLES

Table 1. School District Total Cost Per Pupil Regression Results
Independent: ln(costpp), Obs.: 876, R-sqr.: 0.5618 (between obs. and pred.)

Variable	Coefficient	Std Error	t statistic	p value
ln(enroll)	-0.46060	0.05204	-8.85	0.000***
ln(enroll2)	0.03046	0.00326	9.34	0.000***
ln(attend)	-0.90351	0.53759	-1.68	0.093**
ln(busm)	-0.00232	0.00341	-0.68	0.497
ln(pctrisk)	0.00647	0.00234	2.76	0.006***
ln(pctpov)	0.03783	0.00857	4.41	0.000***
ln(tesala)-IV	0.34619	0.09283	3.73	0.000***
ln(perf)-IV	0.18571	0.06998	2.65	0.008***
metro	-0.02856	0.01502	-1.90	0.058**
suburb	-0.04083	0.01230	-3.32	0.001***
rural	-0.04964	0.01130	-4.39	0.000***
ln(effrte)	-0.75746	0.02287	-33.12	0.000***
ln(schsize)	-0.11857	0.01449	-8.18	0.000***
ln(sec)	0.02502	0.00671	3.73	0.000***
ln(capr)	-0.04151	0.01099	-3.78	0.000***

Significance: * 15% level, ** 10% level, *** 5% level
Instrumented variables ln(tesal), ln(perf) denoted by "IV"

Table 2. School District Transportation Cost Per Pupil Regression Results
Independent: ln(costtpp), Obs: 876, R-sqr.: 0.6143 (between obs. and pred.)

Variable	Coefficient	Std Error	t statistic	p value
ln(enroll)	-0.55807	0.14657	-3.81	0.000***
ln(enroll2)	0.02730	0.00918	2.97	0.003***
ln(attend)	-0.03266	1.51427	-0.02	0.983
ln(busm)	0.21777	0.00960	22.69	0.000***
ln(pctrisk)	-0.00734	0.00662	-1.11	0.267
ln(pctpov)	-0.04700	0.02414	-1.95	0.052**
ln(tesala)-IV	-0.08567	0.21647	-0.33	0.743
ln(perf)-IV	0.09676	0.19713	0.49	0.624
Metro	0.17824	0.04230	4.21	0.000***
Suburb	0.10934	0.03466	3.15	0.002***
rural	0.26227	0.03182	8.24	0.000***
ln(effrte)	-0.29987	0.06442	-4.66	0.000***
ln(schsize)	-0.07147	0.04082	-1.75	0.080**
ln(sec)	0.03571	0.01889	1.89	0.059**
ln(capr)	0.05534	0.03095	1.79	0.074**

Significance: * 15% level, ** 10% level, *** 5% level
Instrumented variables ln(tesal), ln(perf) denoted by "IV"

Table 3. Average Administrative Salary Regression Results
Independent: ln(adsala), Obs.: 876, R-Sqr.: 0.0803 (between obs. and pred.)

Variable	Coefficient	Std Error	t statistic	p value
ln(enroll)	0.47898	0.12497	3.83	0.000***
ln(enroll2)	-0.02990	0.00810	-3.69	0.000***
ln(attend)	0.21931	0.42032	0.52	0.602
ln(busm)	-0.00935	0.00508	-1.84	0.066**
ln(pctrisk)	-0.00955	0.00384	-2.49	0.013***
ln(pctpov)	-0.04778	0.01701	-2.81	0.005***
ln(perf)-IV	-0.07037	0.10387	-0.68	0.498
metro	0.10028	0.02160	4.64	0.000***
suburb	0.07350	0.01988	3.70	0.000***
rural	0.04892	0.01825	2.68	0.007***
ln(effrte)	0.79237	0.16018	4.95	0.000***
ln(schsize)	0.09933	0.02558	3.88	0.000***
ln(sec)	0.00308	0.01106	0.28	0.781
ln(capr)	0.03290	0.01112	2.96	0.003***
ln(costpp)-IV	0.91746	0.17597	5.21	0.000***

Significance: * 15% level, ** 10% level, *** 5% level
Instrumented variables ln(perf), ln(costpp) denoted by "IV

Table 4. Average Teacher Salary Regression Results
Independent: ln(tesala), Obs.: 876, R-sqr.: 0.2114 (between obs. and pred.)

Variable	Coefficient	Std Error	t statistic	p value
ln(enroll)	0.59339	0.10349	5.73	0.000***
ln(enroll2)	-0.03796	0.00679	-5.59	0.000***
ln(attend)	0.65875	0.54866	1.20	0.230
ln(busm)	0.00230	0.00413	0.56	0.578
ln(pctrisk)	-0.00659	0.00311	-2.12	0.035***
ln(pctpov)	-0.03074	0.01359	-2.26	0.024***
ln(perf)-IV	-0.08263	0.09079	-0.91	0.363
Metro	0.06296	0.01747	3.60	0.000***
Suburb	0.04834	0.01642	2.94	0.003***
Rural	0.05329	0.01571	3.39	0.001***
ln(effrte)	0.96612	0.14381	6.72	0.000***
ln(schsize)	0.15448	0.24882	6.21	0.000***
ln(sec)	-0.03465	0.00908	-3.81	0.000***
ln(capr)	0.03147	0.01379	2.28	0.023***
ln(costpp)-IV	1.15154	0.17678	6.51	0.000***

Significance: * 15% level, ** 10% level, *** 5% level
Instrumented variables ln(perf), ln(costpp) denoted by "IV"

Table 5. Per Pupil Administrative Cost Regression Results
Independent: ln(adsalpp), Obs.: 876, R-sqr.: 0.3534 (between obs. and pred.)

Variable	Coefficient	Std Error	t statistic	p value
ln(enroll)	-0.42096	0.26755	-1.57	0.116*
ln(enroll2)	0.02840	0.01706	1.66	0.096**
ln(attend)	0.28269	0.59674	0.47	0.636
ln(busm)	-0.02509	0.01145	-2.19	0.029***
ln(pctrisk)	0.01034	0.00865	1.19	0.233
ln(pctpov)	-0.00566	0.03726	-0.15	0.879
ln(perf)-IV	-0.08180	0.22108	-0.37	0.711
metro	-0.05762	0.04887	-1.18	0.239
suburb	-0.11586	0.04418	-2.62	0.009***
rural	-0.09117	0.04070	-2.24	0.025***
ln(effrte)	0.51783	0.28802	1.80	0.073**
ln(schsize)	-0.09025	0.04497	-2.01	0.045***
ln(sec)	-0.00383	0.02418	-0.16	0.874
ln(capr)	-0.00039	0.01676	-0.02	0.981
ln(costpp)-IV	0.61307	0.30313	2.02	0.043***

Significance: * 15% level, ** 10% level, *** 5% level
Instrumented variables ln(perf), ln(costpp) denoted by "IV"

Table 6. Per Pupil Teacher Cost Regression Results
Independent: ln(tesalpp), Obs.: 876, R-sqr.: 1.0000 (between obs. and pred.)

Variable	Coefficient	Std Error	t statistic	p value
ln(enroll)	-0.000026	0.000104	-0.25	0.803
ln(enroll2)	0.000003	0.000007	0.39	0.700
ln(attend)	0.000617	0.000662	0.93	0.351
ln(busm)	-0.000007	0.000004	-1.77	0.076**
ln(pctrisk)	0.000001	0.000003	0.44	0.660
ln(pctpov)	-0.000009	0.000013	-0.64	0.521
ln(perf)-IV	-0.000073	0.000094	-0.77	0.439
metro	-0.000010	0.000017	-0.58	0.565
suburb	-0.000007	0.000017	-0.44	0.660
rural	-0.000009	0.000166	-0.01	0.996
ln(effrte)	0.999937	0.001451	6893.69	0.000***
ln(schsize)	0.000003	0.000027	0.13	0.899
ln(sec)	0.000019	0.000009	2.05	0.041***
ln(capr)	0.000008	0.000016	0.51	0.613
ln(costpp)-IV	0.999943	0.000195	5141.03	0.000***

Significance: * 15% level, ** 10% level, *** 5% level
Instrumented variables ln(perf), ln(costpp) denoted by "IV"

Table 7. Student Attendance Regression Results
Independent: ln(attend), Obs.: 876, R-sqr.: 0.3630 (between obs. and pred.)

Variable	Coefficient	Std Error	t statistic	p value
ln(enroll)	0.00818	0.00615	1.33	0.184
ln(enroll2)	-0.00061	0.00039	-1.57	0.118*
ln(busm)	0.00058	0.00041	1.43	0.154
ln(tedays)	-0.06550	0.02661	-2.46	0.014***
ln(teexp)	-0.00194	0.00292	-0.67	0.506
ln(pctrisk)	-0.00039	0.00028	-1.43	0.154
ln(pctpov)	-0.00205	0.00087	-2.36	0.018***
ln(pctnomov)	0.00439	0.00366	1.20	0.230
ln(pctnoed)	-0.00346	0.00129	-2.68	0.007***
ln(pci)	0.00485	0.00337	1.44	0.151
ln(tesala)	0.00390	0.00633	0.62	0.538
ln(perf)	0.00889	0.00274	3.25	0.001***
metro	-0.00056	0.00176	-0.32	0.752
suburb	-0.00149	0.00148	-1.01	0.313
rural	-0.00122	0.00136	-0.90	0.370
ln(effrte)	0.00546	0.00356	1.53	0.125*
ln(schsize)	-0.00009	0.00159	-0.05	0.956
ln(sec)	-0.00029	0.00079	-0.37	0.714
ln(capr)	0.00079	0.00084	0.93	0.352
ln(costpp)	0.00061	0.00361	0.17	0.865

Significance: * 15% level, ** 10% level, *** 5% level

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